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Effects of Sustained Communication Time on Reliability of JXTA-Overlay P2P Platform: A Comparison Study for Two Fuzzy-based Systems

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***Abstract*—In P2P systems, each peer has to obtain information of other peers and propagate the information to other peers through neighboring peers. Thus, it is important for each peer to have some number of neighbor peers. Moreover, it is more significant to discuss if each peer has reliable neighbor peers. In reality, each peer might be faulty or might send obsolete, even incorrect information to the other peers. We have implemented a P2P platform called JXTA-Orverlay, which defines a set of protocols that standardize how different devices may communicate and collaborate among them. JXTA-Overlay provides a set of basic functionalities, primitives, intended to be as complete as possible to satisfy the needs of most JXTA-based applications. In this paper, we present two fuzzy-based systems (called FPRS1 and FPRS2) to improve the reliability of JXTA-Overlay P2P platform. We make a comparison study between the fuzzy- based reliability systems. Comparing the complexity of FPRS1 and FPRS2, the FPRS2 is more complex than FPRS1. However, it considers also the sustained communication time which makes the platform more reliable.**

***Keywords*-P2P Systems, JXTA-Overlay, Fuzzy Logic, Network Reliability, Intelligent Algorithm.**

I. Introduction

The Internet is growing every day and the performance of computers is increased exponentially. However, the Internet architecture is based on Client/Server (C/S) topology, therefore can not use efficiently the clients features. Also, with appearance of new technologies such as ad-hoc networks, sensor networks, body networks, home networking, new network devices and applications will appear. Therefore, it is very important to monitor, control and optimize these network devices via communication channels. However, in large-scale networks such as Internet, it is very difficult to control the network devices, because of the security problems.

In order to make the networks secure many security devices are used. The firewalls are used for checking the information between private and public networks. The information is transmitted according to some decided rules and it is very difficult to change the network security policy. Also, there are many small networks and Intranets that do not allow the information coming from other networks. Therefore, recently many researchers are working on Peer-to-Peer (P2P) networks, which are able to overcome the firewalls, NATs and other security devices without changing the network policy. Thus, P2P architectures will be very important for future distributed systems and applications. In such systems, the computational burden of the system can be distributed to peer nodes of the system. Therefore, in decentralized systems users become themselves actors by sharing, contributing and controlling the resources of the system. This characteristic makes P2P systems very interesting for the development of decentralized applications

[1], [2].

In [1], [3], it is proposed a JXTA-based P2P system. JXTA-Overlay is a middleware built on top of the JXTA specification, which defines a set of protocols that standardize how different devices may communicate and collaborate among them. It abstracts a new layer on the top of JXTA through a set of primitive operations and services that are commonly used in JXTA-based applications and provides a set of primitives that can be used by other applications, which will be built on top of the overlay, with complete independence. JXTA-Overlay provides a set of basic functionalities, primitives, intended to be as complete as possible to satisfy the needs of most JXTA-based applications.

In P2P systems, each peer has to obtain information of other peers and propagate the information to other peers through neighboring peers. Thus, it is important for each peer to have some number of neighbor peers. Moreover, it is more significant to discuss if each peer has reliable neighbor peers. In reality, each peer might be faulty or might send obsolete, even incorrect information to the other peers. If a peer is faulty, other peers which receive incorrect information on the faulty peer might reach a wrong decision. Therefore, it is critical to discuss how a peer can trust each of its neighbor peers [4], [5].

The reliability of peers is very important for safe communication in P2P system. The reliability of a peer can be evaluated based on the reputation and interactions with other peers to provide services. However, in order to decide the peer reliability are needed many parameters, which make the problem NP-hard.

Fuzzy Logic (FL) is the logic underlying modes of reasoning which are approximate rather then exact. The importance of FL derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. FL uses linguistic variables to describe the control parameters. By using relatively simple linguistic expressions it is possible to describe and grasp very complex problems. A very important property of the linguistic variables is the capability of describing imprecise parameters.

The concept of a fuzzy set deals with the representation of classes whose boundaries are not determined. It uses a characteristic function, taking values usually in the interval [0, 1]. The fuzzy sets are used for representing linguistic labels. This can be viewed as expressing an uncertainty about the clear-cut meaning of the label. But important point is that the valuation set is supposed to be common to the various linguistic labels that are involved in the given problem.

The fuzzy set theory uses the membership function to encode a preference among the possible interpretations of the corresponding label. A fuzzy set can be defined by examplification, ranking elements according to their typicality with respect to the concept underlying the fuzzy set [6].

In this paper, we present a Fuzzy-based Peer Reliability System (FPRS1) for JXTA-Overlay P2P platform considering three parameters: Data Download Speed (DDS), Local Score (LS) and Number of Interactions (NI) to decide the Peer Reliability (PR). We also implement another FPRS (FPRS2) considering four parameters: DDS, LS, NI and Sustained Communication Time (SCT) to decide the PR.

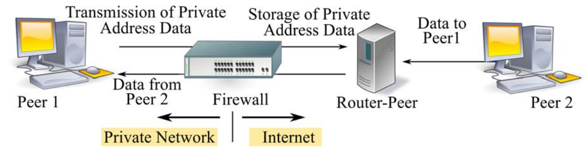

Figure 1. P2P communication.

The structure of this paper is as follows. In Section II, we introduce the Project JXTA and JXTA-Overlay. In Section III, we introduce FL used for control. In Section IV, we present the proposed fuzzy-based peer trustworthiness system. In Section V, we discuss the simulation results. Finally, conclusions and future work are given in Section VI.

II. JXTA Technology and JXTA-Overlay

A. JXTA Technology

JXTA technology is a generalized group of protocols that allow different devices to communicate and collaborate among them. JXTA offers a platform covering basic needs in developing P2P networks [7].

By using the JXTA framework, it is possible that a peer in a private network can be connected to a peer in the Internet by overcoming existing firewalls as shown in Fig. 1. In this figure, the most important entity is the router peer. A router peer is any peer which supports the peer endpoint protocol and routing messages between peer in the JXTA networks. The procedure to overcome the firewall is as follows.

- In the Router Peer is stored the private address of Peer1 by using the HTTP protocol to pass the firewall from Peer1.
- The Router Peer receives the data from Peer2 and access the Private address of Peer1 to transmit the data.

JXTA is an interesting alternative for developing P2P systems and groupware tools to support online teams of students in virtual campuses. In particular, it is appropriate for file sharing given that the protocols allow to develop either pure or mixed P2P networks. This last property is certainly important since pure P2P systems need not the presence of a server for managing the network.

B. JXTA-Overlay

JXTA-Overlay project is an effort to use JXTA technology for building an overlay on top of JXTA offering a set of basic primitives (functionalities) that are most commonly needed in JXTA-based applications [8]–[14]. The proposed overlay comprises the following primitives:

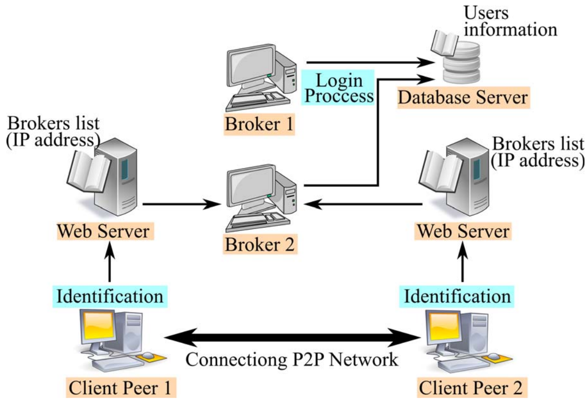

Figure 2. Structure of JXTA-Overlay system.

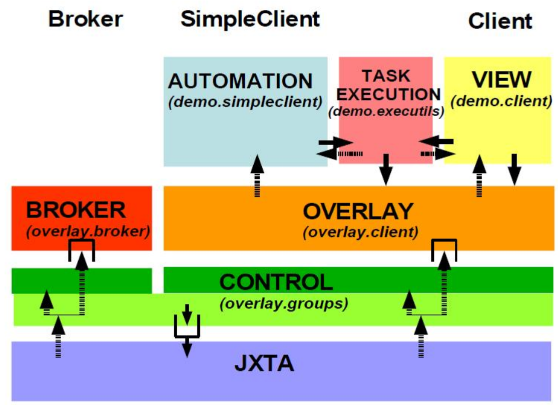

Figure 3. Internal Architecture of JXTA-Overlay.

- peer discovery,
- peer's resources discovery,
- resource allocation,
- task submission and execution,
- file/data sharing, discovery and transmission,
- instant communication,
- peer group functionalities (groups, rooms etc.),
- monitoring of peers, groups and tasks.

This set of basic functionalities is intended to be as complete as possible to satisfy the needs of JXTA-based applications. The overlay is built on top of JXTA layer and provides a set of primitives that can be used by other applications, which on their hand, will be built on top of the overlay, with complete independence. The JXTA-Overlay project has been developed using the ver-2.3 JXTA libraries. In fact, the project offers several improvements of the original JXTA protocols/services in order to increase the reliability of JXTA-based distributed applications and to support group management and file sharing.

The architecture of the P2P distributed platform we have developed using JXTA technology has two main peers: Broker and Client. Altogether these two peers form a new overlay on top of JXTA. The structure of JXTA-Overlay system is shown in Fig 2.

C. Internal Architecture of JXTA-Overlay

Except Broker and Client peers, the JXTA-Overlay has also SimpleClient peers as shown in Fig. 3. The control layer interacts with the JXTA layer, and is divided into two parts: a lower part with functionality common to any kind of peer, and a higher part with functionality specific to Brokers and Clients.

- The common part provides functionality for doing JXTA messaging, discovery and advertisement.
- The Broker specific part provides functionality for managing groups of Brokers and keeping broker statistics.
- The Client specific part provides functionality for managing groups of Clients, keeping client statistics, managing its shareable files, managing the user configuration and creating the connection with a Broker.

The lower part enqueues the JXTA messages to be sent. Whenever a message arrives, the JXTA layer fires an event to the lower layer, which in turn fires a notifications to the upper layers.

III. Application of Fuzzy Logic for Control

The ability of fuzzy sets and possibility theory to model gradual properties or soft constraints whose satisfaction is matter of degree, as well as information pervaded with imprecision and uncertainty, makes them useful in a great variety of applications.

The most popular area of application is Fuzzy Control (FC), since the appearance, especially in Japan, of industrial applications in domestic appliances, process control, and automotive systems, among many other fields.

A. FC

In the FC systems, expert knowledge is encoded in the form of fuzzy rules, which describe recommended actions for different classes of situations represented by fuzzy sets.

In fact, any kind of control law can be modeled by the FC methodology, provided that this law is expressible in terms of "if ... then ..." rules, just like in the case of expert systems. However, FL diverges from the standard expert system approach by providing an interpolation mechanism from several rules. In the contents of complex processes, it may turn out to be more practical to get knowledge from an expert operator than to calculate an optimal control, due to modeling costs or because a model is out of reach.

B. Linguistic Variables

A concept that plays a central role in the application of FL is that of a linguistic variable. The linguistic variables may be viewed as a form of data compression. One linguistic variable may represent many numerical variables. It is suggestive to refer to this form of data compression as granulation [15].

The same effect can be achieved by conventional quantization, but in the case of quantization, the values are intervals, whereas in the case of granulation the values are overlapping fuzzy sets. The advantages of granulation over quantization are as follows:

- it is more general;
- it mimics the way in which humans interpret linguistic values;
- the transition from one linguistic value to a contiguous linguistic value is gradual rather than abrupt, resulting in continuity and robustness.

C. FC Rules

FC describes the algorithm for process control as a fuzzy relation between information about the conditions of the process to be controlled, x and y, and the output for the process z. The control algorithm is given in "if ... then ..." expression, such as:

If x is small and y is big, then z is medium;
If x is big and y is medium, then z is big.

These rules are called *FC rules*. The "if" clause of the rules is called the antecedent and the "then" clause is called consequent. In general, variables x and y are called the input and z the output. The "small" and "big" are fuzzy values for x and y, and they are expressed by fuzzy sets.

Fuzzy controllers are constructed of groups of these FC rules, and when an actual input is given, the output is calculated by means of fuzzy inference.

D. Control Knowledge Base

There are two main tasks in designing the control knowledge base. First, a set of linguistic variables must be selected which describe the values of the main control parameters of the process. Both the input and output parameters must be linguistically defined in this stage using proper term sets. The selection of the level of granularity of a term set for an input variable or an output variable plays an important role in the smoothness of control. Second, a control knowledge base must be developed which uses the above linguistic description of the input and output parameters. Four methods [16]–[19] have been suggested for doing this:

- expert's experience and knowledge;
- modelling the operator's control action;
- modelling a process;
- self organization.

Among the above methods, the first one is the most widely used. In the modeling of the human expert operator's knowledge, fuzzy rules of the form "If Error is small and Change-in-error is small then the Force is small" have been used in several studies [20]–[22]. This method is effective when expert human operators can express the heuristics or the knowledge that they use in controlling a process in terms of rules of the above form.

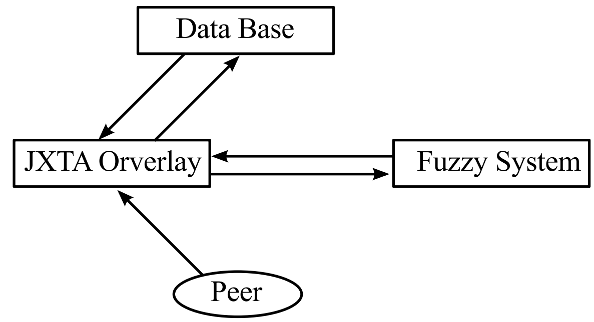

Figure 4. Proposed peer reliability system.

E. Defuzzification Methods

The defuzzification operation produces a non-FC action that best represent the membership function of an inferred FC action. Several defuzzification methods have been suggested in literature. Among them, four methods which have been applied most often are:

- Tsukamoto's Defuzzification Method;
- The Center of Area (COA) Method;
- The Mean of Maximum (MOM) Method;
- Defuzzification when Output of Rules are Function of Their Inputs.

IV. Proposed Fuzzy-Based Peer Reliability Systems

To complete a certain task in JXTA-Overlay network, peers often have to interact with unknown peers. The data download speed that a peer has with other peers in JXTA-Overlay P2P network is a very important factor that affects the peer reliability. In every transaction, peers receive a file and evaluate reliability of the senders with local score from the file. Another important parameter that is connected with peer reliability is the sustained communication time. Selfish peers that benefits from the system without contributing any resources to the network have a low reliability. Every time a peer joins JXTA-Overlay, parameters are fuzzified using fuzzy system, and based on the decision of fuzzy system a reliable peer is selected. After peer selection, the data for this peer are saved in the database as shown in Fig. 4.

The structure FPRS1 is shown in Fig. 5 and the membership functions for FPRS1 are shown in Fig. 6. The Fuzzy Rule Base (FRB) of FPRS1 is shown in Table I and consists of 27 rules.

In this work, we consider the sustained communication time as a new parameter together with three parameters to decide the PR. We call this system FPRS2. The structure of FPRS2 and membership functions are shown in Fig. 7

Table I
FRB OF FPRS1.

No.	DDS	LS	NI	PR
1	Sl	Sm	F	EB
2	Sl	Sm	A	EB
3	Sl	Sm	B	MG
4	Sl	Me	F	EB
5	Sl	Me	A	BD
6	Sl	Me	B	PG
7	Sl	Ma	F	BD
8	Sl	Ma	A	MG
9	Sl	Ma	B	VG
10	Mi	Sm	F	BD
11	Mi	Sm	A	MG
12	Mi	Sm	B	G
13	Mi	Me	F	MG
14	Mi	Me	A	PG
15	Mi	Me	B	VG
16	Mi	Ma	F	PG
17	Mi	Ma	A	VG
18	Mi	Ma	B	VVG
19	Fa	Sm	F	MG
20	Fa	Sm	A	G
21	Fa	Sm	B	VVG
22	Fa	Me	F	G
23	Fa	Me	A	VG
24	Fa	Me	B	VVG
25	Fa	Ma	F	VG
26	Fa	Ma	A	VVG
27	Fa	Ma	B	VVG

Table II
FRB OF FPRS2.

Rule No.	DDS	LS	NI	SCT	PR	Rule No.	DDS	LS	NI	SCT	PR
1	Sl	Sm	F	Sh	EB	41	Mi	Me	A	Me	PG
2	Sl	Sm	F	Me	EB	42	Mi	Me	A	Lo	G
3	Sl	Sm	F	Lo	EB	43	Mi	Me	B	Sh	PG
4	Sl	Sm	A	Sh	EB	44	Mi	Me	B	Me	G
5	Sl	Sm	A	Me	EB	45	Mi	Me	B	Lo	VG
6	Sl	Sm	A	Lo	BD	46	Mi	Ma	F	Sh	VVG
7	Sl	Sm	B	Sh	BD	47	Mi	Ma	F	Me	BD
8	Sl	Sm	B	Me	MG	48	Mi	Ma	F	Lo	MG
9	Sl	Sm	B	Lo	PG	49	Mi	Ma	A	Sh	G
10	Sl	Me	F	Sh	EB	50	Mi	Ma	A	Me	PG
11	Sl	Me	F	Me	EB	51	Mi	Ma	A	Lo	G
12	Sl	Me	F	Lo	BD	52	Mi	Ma	B	Sh	VG
13	Sl	Me	A	Sh	EB	53	Mi	Ma	B	Me	VG
14	Sl	Me	A	Me	BD	54	Mi	Ma	B	Lo	VVG
15	Sl	Me	A	Lo	MG	55	Fa	Sm	F	Sh	VVG
16	Sl	Me	B	Sh	MG	56	Fa	Sm	F	Me	BD
17	Sl	Me	B	Me	PG	57	Fa	Sm	F	Lo	MG
18	Sl	Me	B	Lo	G	58	Fa	Sm	A	Sh	PG
19	Sl	Ma	F	Sh	EB	59	Fa	Sm	A	Me	MG
20	Sl	Ma	F	Me	BD	60	Fa	Sm	A	Lo	PG
21	Sl	Ma	F	Lo	MG	61	Fa	Sm	B	Sh	VG
22	Sl	Ma	A	Sh	BD	62	Fa	Sm	B	Me	G
23	Sl	Ma	A	Me	MG	63	Fa	Sm	B	Lo	VG
24	Sl	Ma	A	Lo	G	64	Fa	Me	F	Sh	VVG
25	Sl	Ma	B	Sh	PG	65	Fa	Me	F	Me	PG
26	Sl	Ma	B	Me	G	66	Fa	Me	F	Lo	G
27	Sl	Ma	B	Lo	VG	67	Fa	Me	A	Sh	PG
28	Mi	Sm	F	Sh	EB	68	Fa	Me	A	Me	VG
29	Mi	Sm	F	Me	EB	69	Fa	Me	A	Lo	VVG
30	Mi	Sm	F	Lo	BD	70	Fa	Me	B	Sh	VG
31	Mi	Sm	A	Sh	BD	71	Fa	Me	B	Me	VVG
32	Mi	Sm	A	Me	MG	72	Fa	Me	B	Lo	VVG
33	Mi	Sm	A	Lo	PG	73	Fa	Ma	F	Sh	PG
34	Mi	Sm	B	Sh	MG	74	Fa	Ma	F	Me	G
35	Mi	Sm	B	Me	PG	75	Fa	Ma	F	Lo	VG
36	Mi	Sm	B	Lo	VG	76	Fa	Ma	A	Sh	VG
37	Mi	Me	F	Sh	EB	77	Fa	Ma	A	Me	VVG
38	Mi	Me	F	Me	BD	78	Fa	Ma	A	Lo	VVG
39	Mi	Me	F	Lo	MG	79	Fa	Ma	B	Sh	VVG
40	Mi	Me	A	Sh	MG	80	Fa	Ma	B	Me	VVG
						81	Fa	Ma	B	Lo	VVG

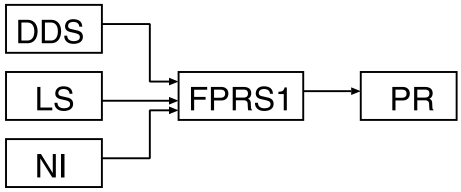

Figure 5. Structure of FPRS1.

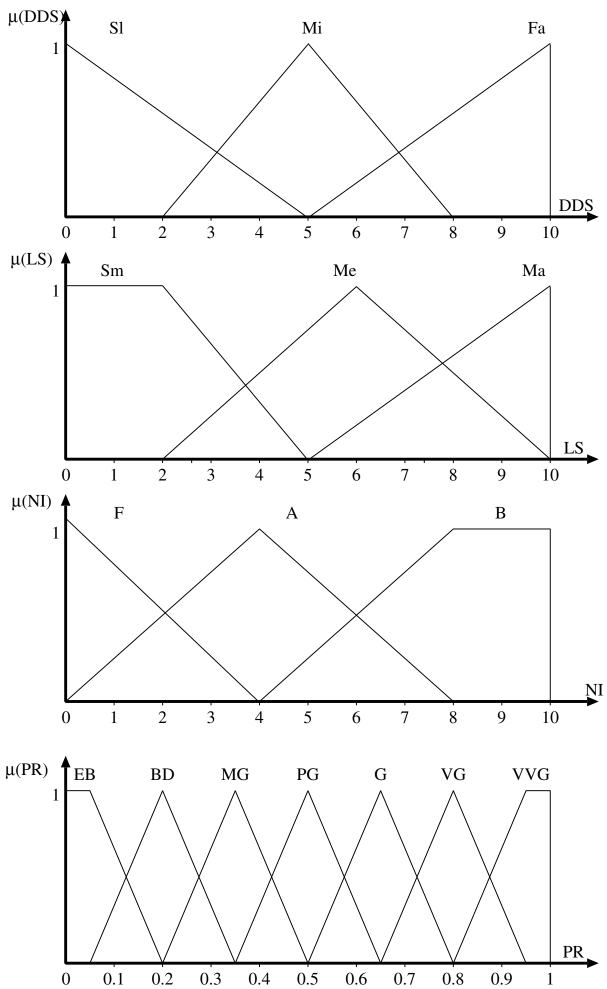

Figure 6. Membership functions of FPRS1.

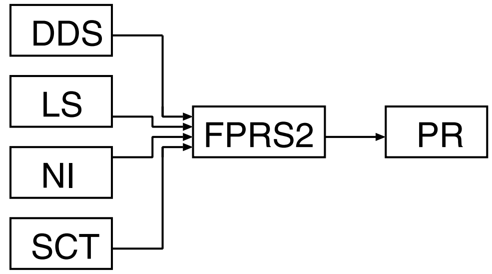

Figure 7. Structure of FPRS2.

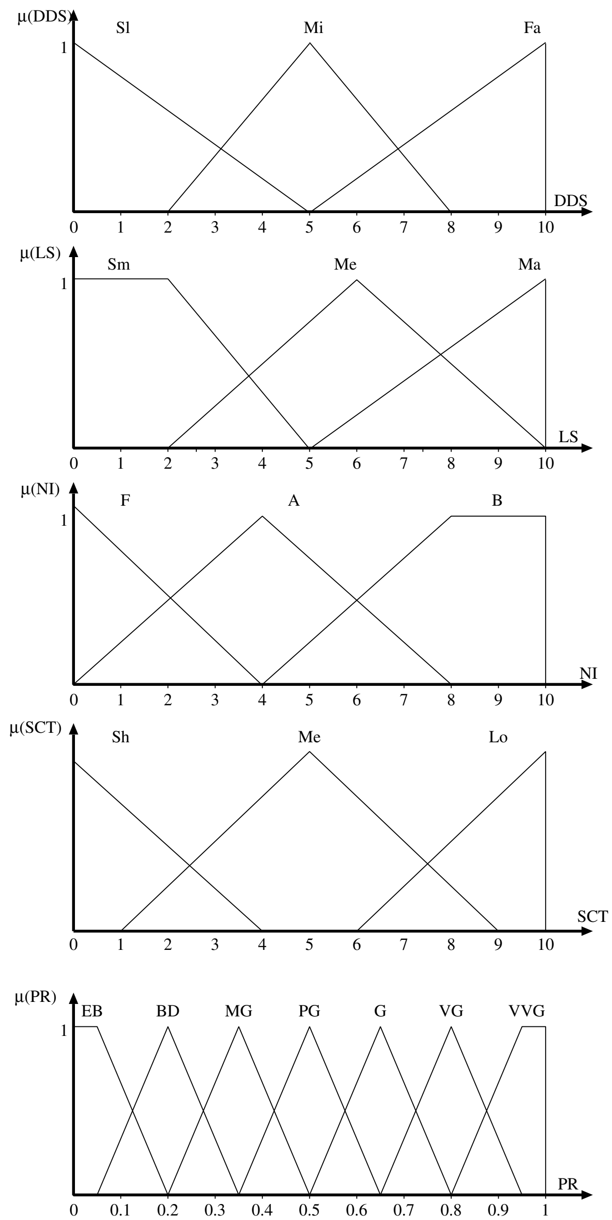

Figure 8. Membership functions of FPRS2.

and Fig. 8, respectively. In Table II, we show the FRB of FPRS2, which consists of 81 rules.

The term sets of *DDS*, *LS* and *NI* and *SCT* are defined respectively as:

$$
\begin{aligned}
DDS &= \{Slow,\ Middle,\ Far\} \\
&= \{Sl,\ Mi,\ Fa\}; \\
LS &= \{Small,\ Medium,\ Many\} \\
&= \{Sm,\ Me,\ Ma\}; \\
NI &= \{Few,\ Average,\ Big\} \\
&= \{F,\ A,\ B\}; \\
SCT &= \{Short,\ Medium,\ Long\} \\
&= \{Sh,\ Me,\ Long\}.
\end{aligned}
$$

and the term set for the output parameter *PR* is defined as:

$$
PR = \begin{pmatrix} Extremely\ Bad \\ Bad \\ Minimally\ Good \\ Partially\ Good \\ Good \\ Very\ Good \\ Very\ Very\ Good \end{pmatrix} = \begin{pmatrix} EB \\ BD \\ MG \\ PG \\ G \\ VG \\ VVG \end{pmatrix}.
$$

V. Simulation Results

In this section, we present the simulation results for our proposed systems. In our systems, we decided the number of term sets by carrying out many simulations.

For FPRS1, we show the relation of DDS, LS, NI and PR in Fig. 9. In this simulation, we consider the NI as a constant parameter. From the simulation results we can clearly distinguish 3 zones. When DDS is less than 2 units the PR is very small. For 2 to 8 units there is a second zone where the PR increases proportionally with the increase of DDS. For more than 8 units, the PR is high. As shown by these figures, with the increasing of NI, DDS and LS, the PR increases.

For FPRS2, in Fig. 10, we show the relation of DDS, LS, NI, SCT and PR, when NI and SCT are considered as constant parameters. In this simulation SCT is 0, so the performance is almost the same with Fig. 9.

In Fig. 11 and Fig. 12, we increase the SCT value to 5 and 10 units, respectively. With the increase of the SCT, the PR increases. When the SCT is high, the PR values of FPRS2 are higher than FPRS1. This show that the SCT has a great effect on the reliability of proposed system.

VI. Conclusions and Future Work

In this paper, we proposed two fuzzy-based systems, in order to evaluate the effects of sustained communication time and select a reliable peer to connect with other peers in JXTA-Overlay plaform. We took into consideration four parameters: DDS, LS, NI and SCT. We evaluated the performance of proposed system by computer simulations.

From the simulations results, we conclude as follows.

- When DDS, LS and NI are high, the reliability is high.
- With the increasing of the SCT, the PR is increased.
- The proposed system can choose reliable peers to connect in JXTA-Overlay platform.
- Comparing the complexity, the FPRS2 is more complex than FPRS1. However, FPRS2 considers also the SCT, which makes the platform more reliable

In the future, we would like to make extensive simulations to evaluate the proposed system and compare the performance of our proposed system with other systems.

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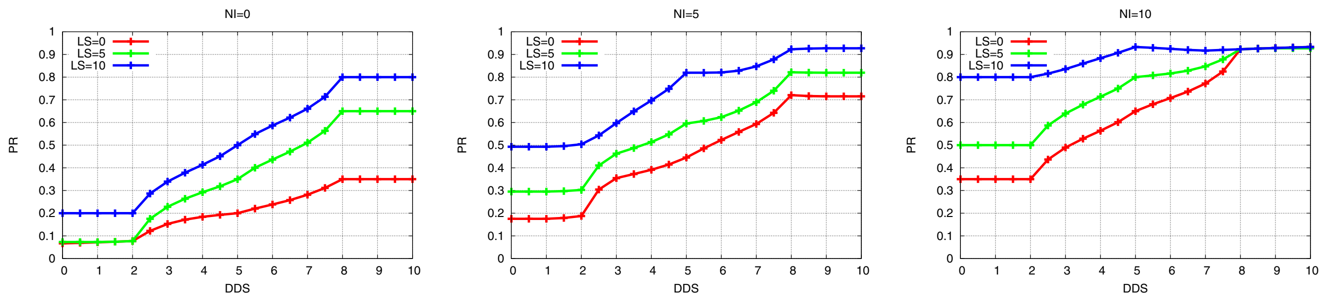
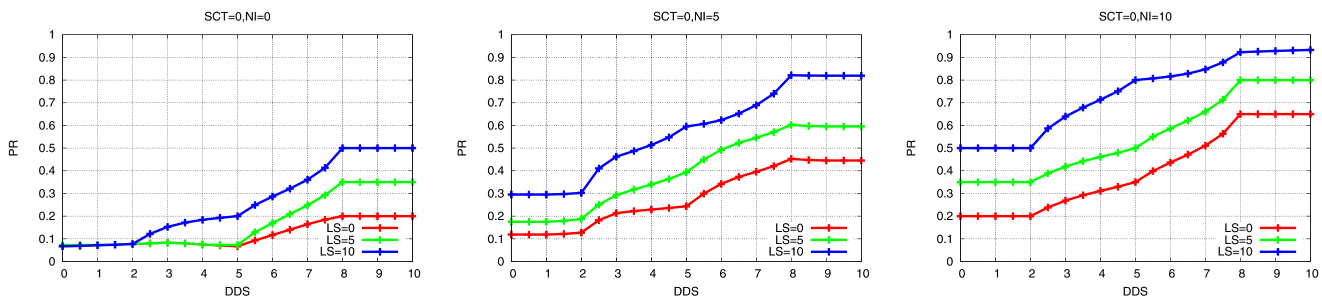


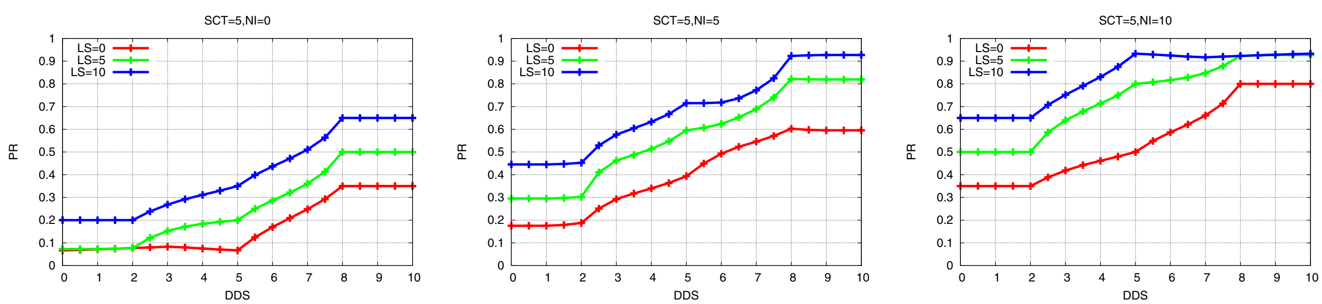
(a) NI=0 (b) NI=5 (c) NI=10

Figure 9. Peer reliability for different NI (FPRS1).



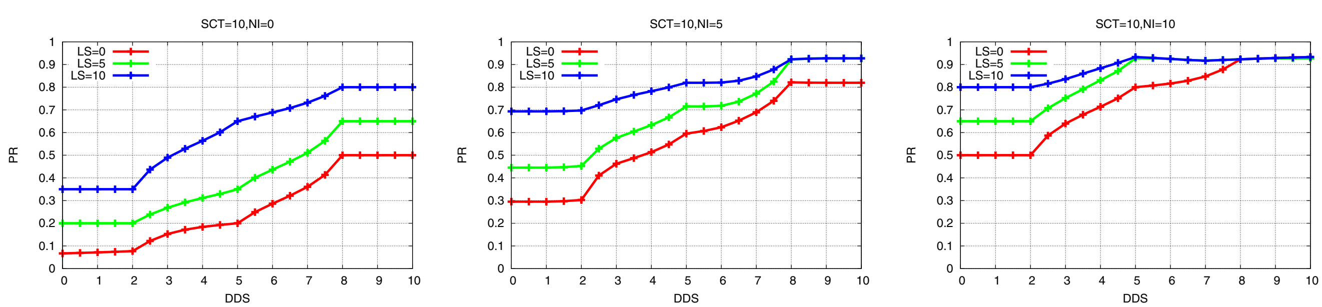
(a) NI=0 (b) NI=5 (c) NI=10

Figure 10. Peer reliability for different NI when the SCT=0 (FPRS2).



(a) NI=0 (b) NI=5 (c) NI=10

Figure 11. Peer reliability for different NI when the SCT=5 (FPRS2).



(a) NI=0 (b) NI=5 (c) NI=10

Figure 12. Peer reliability for different NI when the SCT=10 (FPRS2).

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